SOIL EROSION AND SEDIMENT YIELD

Soil Conservation Service
U. S. Department of Agriculture
Huron, South Dakota 57350

SOIL EROSION and SEDIMENT YIELD in TEN WATER QUALITY STUDY AREAS in SOUTH DAKOTA

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TABLE OF CONTENTS

List of Tables and Figures

SOIL EROSION AND SEDIMENT YIELD
IN
TEN WATER QUALITY STUDY AREAS
IN
SOUTH DAKOTA

Introduction

Intense use of our natural resources over the years has caused a general deterioration of our environment. Some of our air, soil, and water resources have become polluted. Increased public awareness of this situation helped to bring about the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). Section 208 of P.L. 92-500 addresses water pollution problems as it calls for management practices "...(to) be developed and implemented to assure adequate control of sources of pollutants in each state."

The South Dakota Department of Environmental Protection (DEP) has responsibility for formulating a section 208 water quality management plan for South Dakota. Ten watersheds were selected for study to facilitate formulation of the plan. These ten Water Quality Study Areas (WQSA's) were selected by four state planning districts. (See Figure 1.)

It is generally thought that sediment and nutrients are the principal pollutants in South Dakota lakes and streams. 1/, 2/, 3/.

This report outlines more detailed information on soil erosion, sediment sources and quantities, management practices to control sediment, and costs for those practices. This information was developed by the Soil Conservation Service (SCS) for the South Dakota Department of Environmental Protection.

1/ Matthew, F. L., "Water Pollution in South Dakota, Part I: Natural Water Quality and Pollution Sources," 1970, South Dakota Water Resources Institute, S. Dak. State University, Brookings, S. Dak. 34 pages.

2/ "Development Components of the South Dakota Water Plan, Volume II-B" 1977, Division of Resources Management, South Dakota Department of Natural Resources Development, Pierre, S. Dak.

3/ "A Plan for the Classification-Preservation-Restoration of Lakes in Northeastern South Dakota" 1977, State Lakes Preservation Committee, State of South Dakota and the Old West Regional Commission, Pierre, South Dakota.

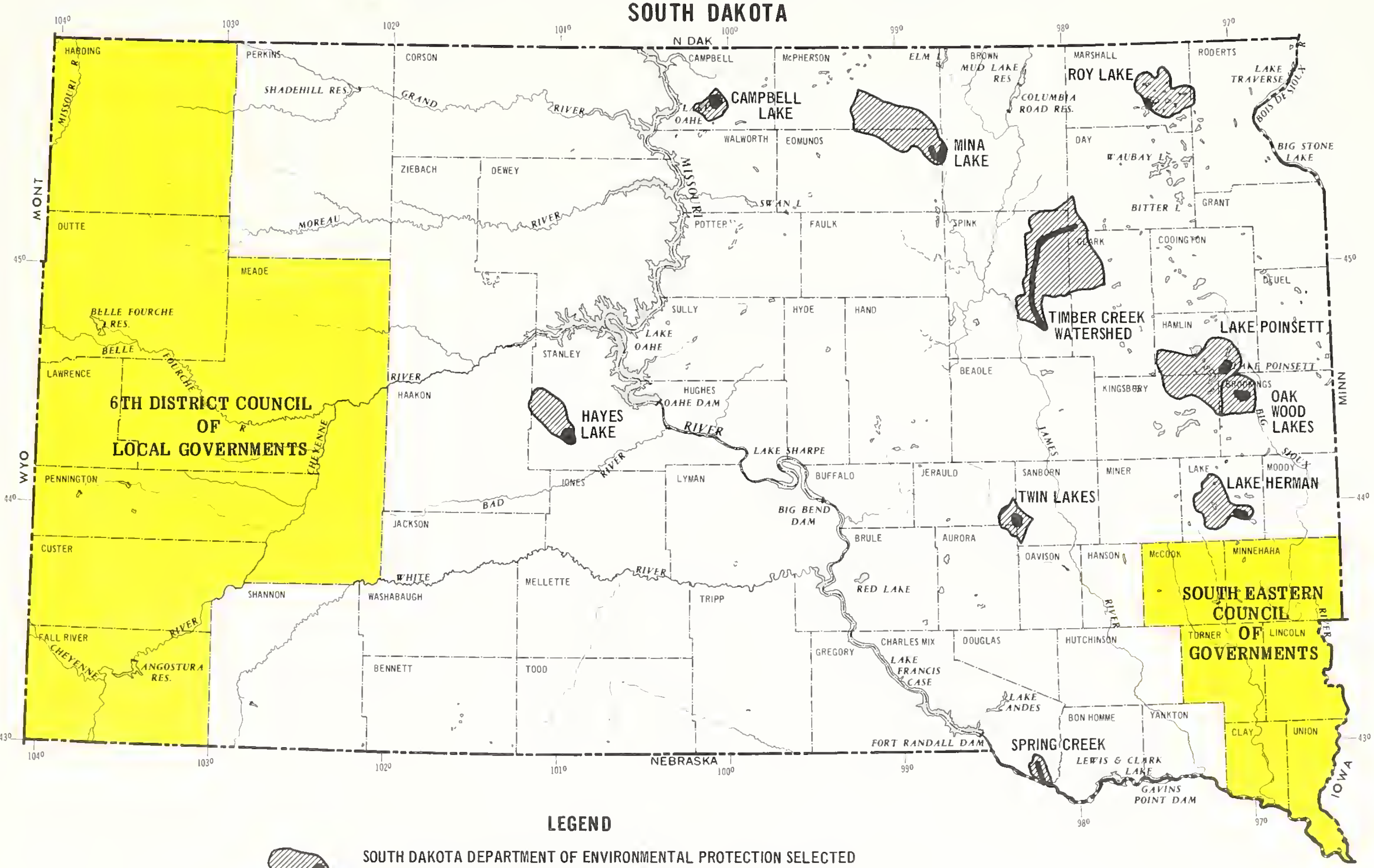
Figure 1.

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

PUBLIC LAW 92-500, FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972 SECTION 208 PLANNING AREAS

SOUTH DAKOTA



LEGEND

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENTAL PROTECTION SELECTED WATERSHED FOR WATER QUALITY MONITORING IN THE NON-DESIGNATED AREAS

DESIGNATED AREA-WIDE WATER QUALITY PLANNING AGENCIES

SCALE 10 0 10 20 30 40 50 60 70 80 MILES

SOURCE:
FAMILY OF MAPS SCS DRAWING NO. 5,S-32,929 (REV. 4-77) AND INFORMATION FROM FIELD TECHNICIANS. ALBERS EQUAL AREA PROJECTION.

USDA-SCS-LINCOLN, NEBR. 1977

12-3-77
5,0-36,220

Summary

This study has determined relative percentages of erosion and sediment yield from cropland, grassland, gullies, streambanks, and other sources. The Universal Soil Loss Equation and direct volume methods were used to estimate gross erosion which was multiplied by estimated sediment delivery ratios to obtain estimated sediment yield.

Sediment was determined to be a pollutant in the ten Water Quality Study Areas (WQSA's) selected by four State Planning Districts and the South Dakota Department of Environmental Protection. Best management practices (BMP's) for this state section 208 water quality management plan thus became those management practices that reduced sediment yield.

A review of the Technical Guide for South Dakota (available at offices of the Soil Conservation Service) indicated soil and water conservation practices (management practices) that are potential BMP's. The relationships between runoff, sediment yield, and management practices, were outlined and, coupled with views of SCS district conservationists, a number of BMP's were selected for the various WQSA's. Costs for BMP's were generally abstracted from the SCS Cost-Return Handbook.

No quantification of reductions in sediment yield due to application of BMP's was attempted. The reasons for this are twofold:

1. The technical data base was inadequate.
2. The potential combinations of BMP's were too great.

Definition and Outline of Study Methods

Erosion

Sheet erosion occurs as water flows overland and moves layers of soil particles loosened by raindrop impact. Rill erosion is movement of soil particles as overland flow concentrates into small channels, or rills, 2 to 12 inches deep. Soil particles are loosened in rills by shear force exerted on the bottom and banks of the rill by the channelized water. Bank sloughing, or miniature landslides, occur as the bottom and lower banks are eroded.

The Universal Soil Loss Equation (USLE),[1/,2/] was used to estimate sheet and rill erosion in the WQSA's. A section in the appendix, "Use of the Universal Soil Loss Equation," explains the factors used in this equation. SCS personnel familiar with each WQSA derived the data needed for the USLE from their field experience, Section III of the South Dakota Technical Guide and detailed soils maps. (General soil associations were used in Timber Creek WQSA.)

Sheet and rill erosion from construction sites, roads and roadbanks was estimated using a direct volume method (multiplying the area of erosion by an estimated rate of erosion and the volume weight of the eroding soil). This method is outlined in the "Erosion and Sediment Inventory Handbook," USDA-SCS, Syracuse, New York (1972) and in "Guide to Sedimentation Investigations," Technical Guide 12, South Technical Service Center, USDA-SCS, Fort Worth, Texas (1976). Sample areas were observed in each WQSA and county highway maps were used to expand the sample data.

1/ Wischmeir, W. H., and Smith, D. D., "Prediction of Rainfall-Erosion Losses from Cropland East of the Rocky Moutains - Guide for Selection of Practises for Soil and Water Conservation," 1965, 47 pages, Agricultural Handbook, No. 282, U.S. Department of Agriculture, Washington, D. C.

2/ "Estimating Soil Loss Resulting from Water and Wind Erosion in South Dakota," June 1977, South Dakota Technical Guide III-1, USDA, SCS, Huron, S. Dak.

Gully and streambank erosion is soil moved by water flowing in channels that are greater than 12 inches deep. The mechanisms of loosening and moving soil particles are the same as in rill erosion except for the larger scale. Lake shore erosion occurs as wave action loosens and moves soil particles. The direct volume method was used to estimate gully, streambank, and lake shore erosion. The effects of ice were also considered in the erosion rate. Sample areas were observed in each WQSA and aerial photographs were used to expand the sample data.

Sediment Yield

Sediment yield is the amount of soil removed from a drainage basin.[3/,4/] It is measured (or estimated) at a point or a stream channel cross section and only represents a fraction of the total soil eroded in the basin above that point.

In this study, gross erosion was estimated and then multiplied by an estimated sediment delivery ratio to obtain sediment yield. This ratio is expressed as a percent and represents the amount of soil removed from a watershed (sediment) divided by the amount of soil moved in the watershed (erosion). It is thus inversely proportional to the amount of deposition occurring between points of erosion and the point where sediment yield is measured.

Many factors affect sediment yield - watershed size, shape, hydrology, channel density, land use, vegetative cover, geology and topography, soil structure, texture, and permeability. The interaction between

3/ "Sedimentation," 1975 National Engineering Handbook, Section 3, USDA, SCS, Washington, D. C.

4/ "Predicting Sediment Yields," in "Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water," 1977, American Society of Agricultural Engineers, Publication 4-77, St. Joseph, Michigan.

all of these factors was subjectively analyzed after a delivery ratio was selected from a drainage area versus delivery ratio curve. This analysis resulted in raising or lowering the curve ratio and the adjusted ratio was used to estimate sediment yield from all sources of sheet and rill erosion. Much higher ratios were used to estimate sediment yield from gully, streambank, and lakeshore erosion.

Best Management Prectices

The Environmental Protection Agency (EPA) has defined best management practices, as published in the Federal Register, as follows:

> "The term, best management practices (BMP), means a practice, or combination of practices, that is determined by a State (or designated areawide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals (40 CFR Part 130)."

Thus best management practices in section 208 water quality management plans are primarily those management practices that are believed to have a beneficial impact on water quality. 5/ Since sediment yield affects water quality adversely in these study areas, management practices that reduce sediment yield will be BMP's. Best management practices were selected from Section III of the South Dakota Technical Guide and costs were taken from the SCS Cost-Return Handbook.

5/ "Environmental Impact of Land Use on Water Quality, Final Report on the Black Creek Project (Summary)," 1977, U.S. Environmental Protection Agency 905/9-77-007-A, Great Lakes National Program Office, Chicago, Illinois.

Soil Erosion and Sediment Yield

General

Soil erosion and the transport mechanisms at work between the eroding area and a point where sediment yield is measured are very complex processes. 1/ The probability of upland eroded soil becoming sediment is inversely proportional to the number of depositional environments it encounters. Estimated sheet and rill erosion derived from the USLE does not account for any deposition. The sediment delivery ratio reflects depositional environments in a watershed.

Streams themselves are complex, dynamic systems that are constantly striving for equilibrium between their sediment load, the amount of water they carry, and the morphology (shape, bank height, slope, etc.) of their channels. 2/ A decrease in sediment load due to improved upland management may cause a stream to increase its channelbank and bottom erosion. The net result might be no change in sediment yield but a change in location and type of soil erosion.

Because of the variety of erosion and sediment yield quantities and sources among the ten WQSA's, each is discussed separately. Table 1 illustrates land use in each of the watersheds 3/ and Table 2 summarizes all the erosion and sediment yield estimates. No detailed discussion of soils, geology, and climate differences between the ten areas is

1/ Foster, G. R., and Meyer, L. D., "Soil Erosion and Sedimentation by Water - An Overview," North Central Region, USDA-SEA and Purdue Agricultural Experiment Station, Purdue Journal Paper No. 6903.

2/ Lane, E. W., "The Importance of Fluvial Morphology in Hydraulic Engineering," ASCE, Volume 81, paper 795, 1955, pages 1-17.

3/ The entire watershed area was studied in only seven of the ten WQSA's. Only the drainage areas emptying directly into Twin Lakes, Roy Lake, and Lake Poinsett were studied. The flat slopes and poorly developed drainage system around Twin Lakes indicated very little sediment yield from eroding upland areas was delivered to the lake. Potholes, sloughs, and other closed depressions provide a similar situation in Roy Lake and Lake Poinsett.

Table 1 - Land Use

WQSA	Drainage Area (Acres)	Land Use (Acres)					Land Use (%)				
		Crop	Range 1/	Pasture	Wood-land	Non-Sediment Contributing 2/	Crop	Range 1/	Pasture	Wood-land	Non-Sedimen Contributing
Roy Lake	1,302	285	853	159	0	5	22	66	12	0	-
Lake Poinsett 3/	2,246	1,281	0	799	96	50	57	0	36	4	2
Twin Lakes	901	605	154	142	0	0	67	17	16	0	0
Hayes Lake	28,237	19,200	8,497	100	0	440	68	30	-	0	2
Campbell Lake	10,701	5,551	4,978	-	0	172	52	46	-	0	2
Lake Herman	42,948	32,223	7,801	-	0	2,924	75	18	-	0	7
Spring-Bull Crk	23,835	12,621	10,568	615	0	31	53	44	3	0	-
Timber Creek	364,779	241,107	123,051	-	0	620	66	34	-	0	-
Mina Lake	161,515	85,340	75,192	-	0	983	53	46	-	0	1
Oakwood Lakes	31,630	19,645	9,805	-	0	2,180	62	31	-	0	7

1/ Also includes hayland and pasture if "Pasture" column has a blank (-).

2/ Generally water, marsh and/or slough.

3/ Twenty acres of urban land (1%) should be included in totals.

South Dakota
Section 208 Study

Table 2 - Soil Erosion and Sediment Yield Estimates

Water Quality Study Areas (Drainage Area in Acres)			Sheet and Rill Erosion and Sediment Yield					Other Erosion and Sediment Yield									
			Crop	Pasture Hayland and Range	Wood-land	Urban and Farmstead	Sub-Total	Gullies	Stream-banks	Lakeshore	Roads	Road-banks	Construction	Mine Spoil	Stream Bottom Scour	Sub-Total	Total
Lake Herman (42,948)	Erosion	Tons/Year	121,494	2,268	-	-	123,762	640	340	377	208	-	-	-	100	1,665	125,427
		Percent of Total	97	2	-	-	99	.5	-	.5	-	-	-	-	-	1	100
	Sed. Yield	Tons/Year	3,645	68	-	-	3,713	190	170	377	11	-	-	-	100	848	4,561
		Percent of Total	80	1	-	-	81	4	4	8	-	-	-	-	3	19	100
Hayes Lake (28,237)	Erosion	Tons/Year	35,093	7,726	-	116	42,935	12,000	3,319	124	-	-	-	-	10	15,453	58,388
		Percent of Total	60	13	-	-	73	21	6	-	-	-	-	-	-	27	100
	Sed. Yield	Tons/Year	2,106	464	-	7	2,577	2,452	1,279	4	-	-	-	-	10	3,745	6,322
		Percent of Total	33	8	-	-	41	39	20	-	-	-	-	-	-	59	100
Lake Campbell (10,701)	Erosion	Tons/Year	15,481	2,117	-	-	17,598	-	420	-	-	4	-	-	100	524	18,122
		Percent of Total	85	12	-	-	97	-	2	-	-	-	-	-	1	3	100
	Sed. Yield	Tons/Year	1,548	212	-	-	1,760	-	315	-	-	-	-	-	100	415	2,175
		Percent of Total	71	10	-	-	81	-	14	-	-	-	-	-	5	19	100
Lake Poinsett (2,246)	Erosion	Tons/Year	7,217	399	4	12	7,632	-	-	694	104	-	33	-	5	836	8,468
		Percent of Total	85	5	-	-	90	-	-	8	1.5	-	.5	-	-	10	100
	Sed. Yield	Tons/Year	1,972	157	1	3	2,133	-	-	694	26	-	33	-	5	758	2,891
		Percent of Total	68	5.5	-	-	73.5	-	-	24	1	-	1	-	.5	26.5	100
Twin Lakes (901)	Erosion	Tons/Year	1,971	13	-	-	1,984	-	-	39	28	-	-	-	-	67	2,051
		Percent of Total	96	-	-	-	96	-	-	2	2	-	-	-	-	4	100
	Sed. Yield	Tons/Year	308	1	-	-	309	-	-	39	14	-	-	-	-	53	362
		Percent of Total	85	-	-	-	85	-	-	11	4	-	-	-	-	15	100

South Dakota
Section 208 Study

Table 2 - Soil Erosion and Sediment Yield Estimates

Water Quality Study Areas (Drainage Area in Acres)			Sheet and Rill Erosion and Sediment Yield					Other Erosion and Sediment Yield									
			Crop	Pasture Hayland and Range	Woodland	Urban and Farmstead	Sub-Total	Gullies	Streambanks	Lakeshore	Roads	Roadbanks	Construction	Mine Spoil	Stream Bottom Scour	Sub-Total	Total
Roy Lake (1,302)	Erosion	Tons/Year	2,385	236	-	-	2,621	-	-	520	-	-	34	-	-	554	3,175
		Percent of Total	75	8	-	-	83	-	-	16	-	-	1	-	-	17	100
	Sed. Yield	Tons/Year	480	45	-	-	525	-	-	520	-	-	34	-	-	554	1,079
		Percent of Total	45	4	-	-	49	-	-	48	-	-	3	-	-	51	100
Spring-Bull Creek 1/ (23,835)	Erosion	Tons/Year	59,316	43,734	-	-	103,050	36,192	28,255	-	-	283	-	-	2,000	66,730	169,780
		Percent of Total	35	26	-	-	61	21	17	-	-	-	-	-	1	39	100
	Sed. Yield	Tons/Year	4,893	3,607	-	-	8,500	5,972	6,216	-	-	23	-	-	1,100	13,311	21,811
		Percent of Total	22	17	-	-	39	27	28	-	-	-	-	-	6	61	100
Oakwood Lakes (31,630)	Erosion	Tons/Year	73,548	4,526	-	-	78,074	-	-	7,885	-	-	-	-	-	7,885	85,959
		Percent of Total	86	5	-	-	91	-	-	9	-	-	-	-	-	9	100
	Sed. Yield	Tons/Year	4,413	272	-	-	4,685	-	-	7,885	-	-	-	-	-	7,885	12,570
		Percent of Total	35	2	-	-	37	-	-	63	-	-	-	-	-	63	100
Mina Lake (161,515)	Erosion	Tons/Year	102,428	7,562	-	-	109,990	-	-	-	-	-	-	-	10	10	110,000
		Percent of Total	93	7	-	-	100	-	-	-	-	-	-	-	-	-	100
	Sed. Yield	Tons/Year	5,121	378	-	-	5,499	-	-	-	-	-	-	-	10	10	5,509
		Percent of Total	93	7	-	-	100	-	-	-	-	-	-	-	-	-	100
Timber Creek (364,779)	Erosion	Tons/Year	488,889	40,152	-	-	529,041	2,050	2,655	-	-	2,810	-	-	100	7,615	536,656
		Percent of Total	91	7.5	-	-	98.5	.5	.5	-	-	.5	-	-	-	1.5	100
	Sed. Yield	Tons/Year	12,222	1,004	-	-	13,226	615	796	-	-	140	-	-	100	1,651	14,877
		Percent of Total	82	7	-	-	89	5	5	-	-	1	-	-	-	11	100

1/ Two SCS floodwater retarding structures control approximately 47% of the drainage area (with 98% trap efficiency) so only 55% of the estimated sediment yield is delivered to the mouth of the watershed.

Table 3 - Comparison of Soil Erosion and Sediment Yield by WQSA and Estimated Lake Capacity Loss

WQSA	Contributing Drainage Area (mi2)	Soil Erosion (tons/mi2/yr)		Sediment Yield (tons/mi2/yr)		Total Sediment Yield 1/ (ac-ft/yr)	Capacity of Lake or Reservoir 2/ (acre-feet)	Capacity Loss of Lake or Reservoir (%/yr)
		Sheet & Rill	Other	Sheet & Rill	Other			
Lake Herman	60.41	2,049	28	61	14	3.5	6,720	0.05
Hayes Lake	44.12	973	350	58	85	4.8	572	0.80
Lake Campbell	16.72	1,052	31	105	25	1.7	320	0.50
Lake Poinsett	3.51	2,174	238	608	216	2.2	78,656	0.02 3/
Twin Lakes	1.41	1,407	48	219	38	0.3	3,600	0.02 3/
Roy Lake	2.03	1,291	273	259	273	0.8	15,206	0.03 3/
Spring-Bull Creek	17.50	3,121	2,021	486	761	16.7	-	-
Oakwood Lakes	45.96	1,699	172	102	172	9.6	10,240	0.09
Mina Lake	252.37	436	-	22	-	4.2	5,635	0.07
Timber Creek	569.97	928	13	23	3	11.4	-	-

1/ Submerged sediment deposits may have volume weights (pcf - pounds per cubic feet) of 1-50 pcf and older deposits may range from 30-100 pcf depending on sediment texture and history of dessication and compaction. A volume weight of 60 pcf was used to convert tons to acre-feet using (tons divided by volume weight) x 0.04591 = acre-feet.

2/ Surface area of lake (acres) x average lake depth (feet) in 1978.

3/ Estimated-using estimated total sediment yield from entire drainage area of 13.5 acre-feet/yr for Lake Poinsett, 4.6 acre-feet/yr for Roy Lake, and 0.7 acre-feet/yr for Twin Lakes.

provided because of the great amount of data already published. References can be obtained in the state library in Pierre, South Dakota, or any of the South Dakota colleges or universities.

The percents of erosion and sediment yield from cropland and rangeland appear very high in some Water Quality Study Areas. This is due more to the absence of erosion and sediment yield from other sources than to the severity of erosion on cropland and rangeland. Table 3 provides a perspective on the severity of the erosion involved and also on the significance of the sediment produced by all sources in the different Water Quality Study Areas.

Hayes Lake

Hayes Lake is the only WQSA west of the Missouri River. This watershed (28,237 acres) lies in the Pierre Hills physiographic province in Stanley County and its upper border is the Bad-Cheyenne River divide. The lake is a Works Projects Administration reservoir built in 1934 and is located just above the breaks along the Bad River valley wall. Clayey soils over Pierre shale occur on uplands with long smooth slopes. Short, steeper slopes are found along well-defined drainageways. Some Tertiary sands and gravels - remnants of ancient terraces - are found in the uplands.

Land use is 68 percent cropland and 30 percent rangeland, a reversal of use prior to 1973. Distribution of crops in the watershed is about 48 percent small grains, 15 percent rowcrops, 3 percent alfalfa, and 34 percent fallow during an average year. Rangeland is in 60 percent Excellent and Good Condition Classes and 40 percent Fair and Poor Condition Classes. Sheet and rill erosion from cropland and rangeland are the major erosion sources (73 percent), but gullies and streambanks are the major sediment sources (59 percent). There are approximately 150 gullies and almost 50 miles of eroding streambanks in the watershed. (About 30 percent of the 176 miles of streambanks are eroding.)

A 1937 SCS sediment survey of the lake showed an annual sediment yield of 220 tons per square mile of drainage area (tons/mi^2). This section 208 study showed an estimated average annual sediment yield of 143 tons/mi^2 and a sediment survey completed in June of 1978 showed an annual rate of 140 tons/mi^2 since 1937. (The apparent discrepancy between 220 and 143 tons/mi^2 can be explained by noting that the sediment record in 1937

was only 4.2 years in length and heavy rains preceded by a severe drought occurred in those 4 years. These conditons provided the abnormally high sediment rate of 220 tons/mi^2/yr.)

Spring-Bull Creek

Spring-Bull Creek WQSA (23,835 acres) lies in the southern tip of the Missouri Coteau physiographic province in southeastern Charles Mix County. The upper third of the watershed is level to rolling with closed depressions and poorly developed drainageways. Narrow, V-shaped valleys in moderate to steeply rolling terrain typify the middle third of the watershed while the lower third is primarily Missouri River Bluffs - an area of steep, hilly and broken land with deeply cut drainages. Soils are generally clayey to loamy, grading from deep to shallow from north to south.

Land use is almost evenly divided between cropland and rangeland. Small grain and rowcrops are the dominant crops in the watershed along with some alfalfa. Most of the native rangeland is in Good Condition Class. Cropland and rangeland contribute approximately 60 percent of the estimated total erosion in the watershed. Gullies and streambanks contribute approximately 40 percent of the erosion but they contribute about 55 percent of the total sediment yield. There are over 200 gullies throughout the lower two-thirds of the watershed and 38 percent (about 60 miles) of the 155 miles of streambanks are eroding.

Lake Campbell

Lake Campbell WQSA (10,701 acres) is in Campbell County in the Missouri Coteau physiographic province. The lake is a Works Projects Administration reservoir built in 1934. Loamy soils developed on glacial drift mantle this WQSA. Slight rises and swales with closed depressions characterize the landscape, although rocky hills and ridges with potholes are found in the northwest corner of the watershed. Fairly well-defined channels are cut into glacial-drainage valleys.

Land use is almost evenly divided between cropland and rangeland. There was 60 percent cropland in the watershed in 1973. Small grain is the dominant crop while alfalfa and some rowcrops are also grown. Most of the rangeland is in Good Condition Class.

Almost all the total estimated erosion (97 percent) appears to be from cropland and rangeland. No gullies were observed in the sampled portions of the watershed and only 9 percent of the 70 miles of streambanks were eroding. No lakeshore erosion was evident. Eighty-one percent of the sediment yield was estimated to be from cropland and rangeland.

A sediment survey of the lake was made in 1973 by the Soil Conservation Service. The average annual rate of sediment yield was 200 tons/mi^2 of drainage area. (The estimated volume weight of that sediment appeared to be too high - 65 pounds per cubic foot- which would give a high estimate of tons/mi^2.) This study showed an estimated sediment yield of 130 tons/mi^2.

Mina Lake

Mina Lake is a reservoir on the southern end of the Brown-Edmunds County line. Its watershed (161,515 acres) lies predominantly in Edmunds and McPherson Counties just east of the Missouri Coteau in the James Basin physiographic province. The topography is nearly level to gently sloping with some hills in the uppermost end. Many small depressions and potholes dot the landscape. Drainage is poorly developed except for a few major creeks which lie in fairly steep-walled, glacial-drainage valleys. Soils are generally deep and loamy formed in glacial drift, although many soils in the lower two-thirds of the watershed have a claypan subsoil. Some Pierre shale outcrops occur in the valley walls and lakeshores.

Land use in the Mina Lake watershed is almost evenly divided between cropland (53 percent) and rangeland (46 percent). Small grain (over 50 percent), rowcrops (about 15 percent), and alfalfa (about 30 percent) are grown. Rangeland is in Fair to Good Condition Classes.

Most of the erosion and sediment yield in the watershed is from cropland and rangeland. Some gully or streambank erosion was noted in the lower reaches of the watershed and some lakeshore erosion was also noted. The amounts of these three types of erosion, and their sediment yield, were considered insignificant in this study.

Lake Herman

Lake Herman WQSA (42,948 acres) lies in Lake County in the southern end of the Prairie Coteau physiographic province. Its western edge is the East Fork of the Vermillion-Big Sioux River divide. The greatest portion of the watershed is nearly level to gently sloping with some moderately well-developed drainages. Many potholes and sloughs are scattered throughout the upland portions of the watershed and most soils are silty to clayey in glacial drift.

About 75 percent of the watershed is cropland (45 percent small grains, 45 percent rowcrops, and 10 percent alfalfa). Very little rangeland (in Fair to Good Condition Classes) is found in the watershed. Hayland and pastureland occurs along many of the creeks and forms about 18 percent of the watershed. The remaining 7 percent of land area consists of sloughs, potholes, and water (non-sediment contributing areas).

Almost all the erosion in the watershed is from cropland and grassland (99 percent) and 80 percent of the sediment yield comes from these sources. Only eight gullies were found in the watershed and only 11 percent (about 14 miles) of the 122 miles of streambanks were eroding. Sediment yield from lakeshore erosion equals that of gullies and streambanks.

Timber Creek

Timber Creek WQSA (364,779 acres) drains parts of four counties before it empties into the James River south of Frankfort in Spink County. It lies primarily in the James Basin physiographic province. The western half of the watershed is in the Dakota Lake Plain which is part of the James Basin. The Lake Plain is nearly level and cut by shallow, flat-bottomed streams. The eastern edge of the watershed forms the James-Big Sioux River divide and is in the Prairie Coteau physiographic province. This area is characterized by hilly terrain with many closed depressions and poorly defined drainages. Deeply dissected streams come off this highland area and eventually merge with the Lake Plain drainages. Silty clay soils in glacial drift are dominant.

Land use in Timber Creek WQSA is primarily cropland (66 percent) with rangeland forming the balance. About 50 percent of the cropland is small grain, 30 percent is rowcrops, and the rest is divided between alfalfa and summer fallow.

Almost 99 percent of the erosion in the watershed is from cropland and rangeland. Sediment yield from these two sources is almost 90 percent. Streambanks and gullies contribute 10 percent of the total sediment yield.

Twin Lakes

Twin Lakes WQSA (901 acres) lies on the southern end of the Jerauld-Sanborn County line. It is within the James Basin physiographic province and most of the watershed is level to gently undulating. Except for a few well-defined glacial-drainage valleys, most of the drainage is poorly defined. Many closed depressions dot the landscape. Soils are generally loamy being formed in glacial drift. Because of the very low sediment yields from this type topography, only the drainage area in the immediate vicinity of the lake was studied.

Twin Lakes WQSA is primarily cropland (67 percent) with some rangeland (33 percent). Approximately 96 percent of the total erosion and 85 percent of the total sediment yield is from the cropland and rangeland. The lakeshore and roads contribute the remaining 15 percent of the sediment yield. No gullies or streambank erosion was observed in the study area.

Roy Lake

Roy Lake WQSA (1,302 acres) is a natural lake in Marshall County within the Prairie Coteau physiographic province. Topography is gently undulating to rolling with many lakes, sloughs, and closed depressions. Short length drainages often terminate in the many depressions. Loamy and silty soils formed in glacial drift are dominant. Because of the very low sediment yields from the above type of topography, only the drainage area in the immediate vicinity of the lake was studied.

About 22 percent of the watershed is cropland which is almost entirely fall plowed small grains. The remainder of the watershed is primarily native grass with some pasture.

Erosion from cropland and rangeland is about 83 percent and almost 50 percent of the total sediment yield is from these sources. Almost all the remaining erosion and sediment yield is from the lakeshore.

Lake Poinsett

Lake Poinsett WQSA (2,246 acres) is in southern Hamlin County within the Prairie Coteau physiographic province. Topography is gently undulating to rolling with many lakes, sloughs, and closed depressions. Drainage is poorly defined. Silty loam soils formed in glacial drift are common. Because of the very low sediment yields from the type of topography found in this WQSA, only the drainage area in the immediate vicinity of the lake was studied.

Almost 60 percent of the area is cropland and the remainder is pastureland. Rowcrops and small grains, with fall plowing, are the primary crops in the area. About 90 percent of the total erosion and 74 percent of the total sediment yield are from cropland and pastureland. The remainder of the erosion and sediment yield is primarily from the lakeshore.

Oakwood Lakes

Oakwood Lakes WQSA (31,630 acres) lies near the southern end of the Prairie Coteau physiographic province. It is in the northwest corner of Brookings County in the Big Sioux River basin. The north and west portions of this WQSA are gently undulating with closed depressions and moderately deep silty loam soils. The glacial drift landscape is rolling in the south half of the watershed with steep-sided knobs interspersed with gentler relief. Silty loam soils here are thin. Most of the major drainages lie in steep-sided glacial-drainage valleys.

Sixty-two percent of the land is used for cropland and 31 percent is pastureland and rangeland. Seven percent of the watershed is non-sediment contributing. The dominant crops are small grains and rowcrops with some alfalfa. Very little streambank erosion was evident and the few gullies noticed were grass covered and seemingly healed. Lakeshore erosion contributes over 60 percent of the sediment yield to Oakwood Lakes. Sheet and rill erosion from cropland and rangeland was 91 percent of the total erosion but only 37 percent of the total sediment yield.

Best Management Practices

General

Best management practices (BMP's) in section 208 water quality management planning have been defined as those management practices (MP's) that are believed to have a beneficial impact on water quality. Since reduction of sediment yield and nutrients will have the most beneficial impact on water quality in Water Quality Study Areas in South Dakota, management practices that reduce sediment yield and nutrients, and that are also practical and cost-effective, are best management practices.

Structural MP's such as sediment traps in channels or debris basins (dams) across channels, are obvious MP's that can reduce sediment yield by storage. Also obvious is the fact that the location of these structures is critical in determining their usefulness in storing sediment (improving water quality). A dam built at the top of a watershed will do very little to reduce sediment yield at the mouth of that watershed, and installation of such a dam could not be called a BMP.

Cultural MP's, such as minimum or conservation tillage, contour farming, or range management, generally reduce soil erosion. These practices become BMP's if they also reduce sediment yield. The location of applied cultural MP's becomes the key to discerning which of those practices significantly affect sediment yields and thus become BMP's. As an example, an upland eroding area surrounded by potholes and sloughs may contribute very little to sediment yield measured at the mouth of

that watershed. This could be true even though the erosion rate on that upland area was much greater than 5 tons/acre/year. In other words, application of cultural MP's that control soil erosion rates within selected tolerable limits 1/ is no guarantee for reduced sediment yield or improved water quality. 2/

BMP's and Sediment Yield

The study methods used in this report only provided average soil erosion rates for various land uses on various soils. Erosion rates in any one WQSA may vary from none to ten tons per acre per year, or more, but the extent of slightly or severely eroding fields is masked by the average rates obtained in this study. In a similar manner, the areas having high and low sediment yields are also masked by the one "average" delivery ratio selected for each WQSA. It is essential to locate high sediment yielding areas before actual BMP's can be selected that are practical and cost-effective.

Following is a list of factors that contribute to high sediment yield. The list is not comprehensive, nor is the numerical order of the factors significant. The larger number of factors that apply to a field, the greater probability that high sediment yields can be expected from that field. Those high sediment yielding areas should have high priority for application of BMP's.

1/ Soil Loss Tolerance Factor (T), USDA-SCS Advisory SOILS-SD-2, February 27, 1978.

2/ Misuse of the Universal Soil Loss Equation (USLE), USDA-SCS Advisory EVT-6, March 9, 1978.

1. Bare ground or ground with inadequate vegetative cover
2. Long or steep slopes
3. Tillage less than 30 feet from a channel
4. No field border of grass
5. Clay and silt-textured and dispersed soils
6. Gullies or eroding streambanks
7. Well-developed drainage systems
8. Long and narrow drainage areas

Some attention should also be given to the time of year the above conditions exist. Generally, South Dakota's most erosive rainfalls occur during June, July, and August. 3/ Sediment yield is not directly related to the amount of rainfall in a watershed, however, except for watersheds of 1 or 2 acres. In very large watersheds (greater than 10,000 acres), sediment yield is directly related to runoff. 4/ Runoff, in turn, is dependent on rainfall, soil moisture, ground cover and, somewhat, on drainage system efficiency. This means that the months of the year when the greatest amounts of erosion occur are not necessarily identical to the months that sediment yields are high, especially in large watersheds. It also means that reducing runoff may effect a reduction in sediment yield from large watersheds. 5/

3/ See footnote 2 page 3.

4/ McGiunnes, J.L., Harrold, L.L., and Edwards, W.M., (1971), "Relation of Rainfall Energy and Streamflow to Sediment Yield from Small and Large Watersheds," Journal of Soil and Water Conservation, Nov.-Dec., 1971, pages 233-235.

5/ It should be noted that while many people accept as fact that soil and water conservation practices (management practices) reduce runoff, and sediment and nutrient concentrations in runoff, little research has been done to date to quantify those reductions. Where and when rainfall occurs in a watershed, as well as intensity and duration of storms, all affect runoff, (and sediment and nutrient concentrations in runoff), as measured at the mouth of that watershed. When a researcher can correctly adjust numbers from water samples collected at the mouth of a watershed for the variety of rainfall events that can occur anywhere in the watershed and for the variety of soils and land uses affected by those rainfall events in that watershed then, perhaps, those numbers may have meaning.

Large storms versus small storms and their effects on sediment yield should also be considered when selecting BMP's. In a study of the Black Creek Watershed in Indiana (as well as in other studies) it was found that three large storms which occurred during the 2-year study period accounted for 50 percent of the total runoff during that period and 73 to 86 percent of the total sediment yield.[6/] However, it was also determined in that study that BMP's to reduce sediment yield from large storms (primarily structural MP's) were not cost-effective for that area. Generally, in South Dakota, BMP's that control sediment yield resulting from small storms will be emphasized, and further study will be required to determine cost-effectiveness of control for large storms.

BMP's and Nutrients

To this point, much has been said about controlling sediment yield, but nutrients are also part of the water quality problem in South Dakota. If these nutrients (phosphorus (P) and nitrogen (N),primarily) are adsorbed on the surface of the clay and organic fraction of the sediment, control of the sediment will also effectively control the nutrients. If the nutrients are dissolved and carried off the land in runoff water, or removed through ground water flow, control of sediment will have little beneficial impact on reducing nutrient concentrations in streams and lakes.

Before proper BMP's can be selected, the ratio of nutrient concentrations in the sediment and in the water (surface runoff and ground water) must be determined. It is also necessary, of course, to determine what the background concentrations of nutrients are in order to determine if agricultural practices are actually causing pollution (or increased concentrations of nutrients). Instead of applying practices to control sediment and water movement, a wiser course may lie in applying practices that control rural and urban wastes and the application of manure, fertilizer, and pesticides. These may be the most cost-effective and efficient BMP's to control nutrients.

6/ See 5/, page 5.

BMP's and Ten WQSA's

General

There are many factors to consider when deciding if a given management practice is a BMP, as the previous sections have indicated. A BMP in one WQSA may not be a BMP in a different area.

This study has determined relative percentages of erosion and sediment yield from cropland, grassland, gullies, streambanks, lakeshores, and other sources. No attempts were made to pinpoint high sediment yield areas within the individual source areas. Certain MP's are listed for each WQSA that are BMP's when applied to the appropriate areas within each watershed. The previous sections provide guidelines for making that selection.

Each of the management practices listed could be used alone. However, the most complete erosion control and sediment yield reduction will result when a combination of practices are applied. Such a combination, which includes practices needed to protect the resource base, is called a Resource Management System (RMS). Erosion and sediment yield rates were not estimated for any specific RMS since various combinations of practices will result in different rates.[7/] It is impossible to select a RMS for any WQSA arbitrarily. Getting RMS's applied is a job of education and salesmanship in each WQSA. Each landowner and operator will judge the benefits of any RMS to his or her particular operation before a decision to apply the RMS is made.

The following performance standards apply for selection of BMP's for any watershed:

1. Applying erosion control practices that will reduce soil movement by wind and water to a level within the tolerable limit for each soil, and which will deliver surface water runoff to natural watercourses without creating gullies.
2. Planning the amount, timing, and placement of pesticides, fertilizers, manure[8/], and other chemicals to avoid contamination of surface and/or ground water. (Guidelines available at each county office of the Cooperative Extension Service.)

7/ Also see 5/, page 15.

8/ SCS is currently developing a Waste Utilization specification outlining the proper use of manure on fields.

3. Treating or handling all livestock (feedlot) and other agricultural waste products to prevent contamination of surface and/or ground water.

Although they are not a performance standard, field borders or grass filter strips remove sediment from overland flows and should be considered a potential BMP in any watershed. The borders or strips should be at least 30 feet wide and are very important along streams.

Grassed waterways (at $500/acre flat rate installation cost) are designed to deliver surface runoff to a natural watercourse without creating gullies, and, as such, are an integral part of the performance standards listed above. If the waterway traps sediment, it eventually defeats the designed purpose and erosion outside the waterway is likely to occur.

Hayes Lake

The primary sources of sediment yield in this WQSA are gullies and streambanks (59 percent). There are approximately 150 gullies and 50 miles of eroding streambanks in the watershed. Small dams (grade stabilization structures or debris basins) will store sediment from all sources and control some gully and streambank erosion.

Based on records of costs of grade stabilization structures to control gullies, each small dam may cost about $20,500 and will control 350 acres of drainage. If 50 such structures were built in this watershed, over $1 million would have to be spent with an estimated reduction in erosion of 15 percent and total sediment yield of 50 percent. Over 70 small dams have been built in this watershed to date, so many good sites are no longer available. The sediment storage benefits are only temporary, also. As the pools fill with sediment, a new cycle of erosion will begin cutting through the spillway and pool and the stored sediment will once again become part of that system of dynamic equilibrium common to all streams.

Controlling streambank erosion and its sediment yield usually involves riprapping. The cost of shaping the streambanks is variable but the cost of riprap, bedding material, and placement of the material ranges from $14 to $21 for 1 square yard. Rock-filled wire baskets (gabions) cost approximately $40 per square yard.9/

Again, controlling eroding streambanks is a difficult task due to the equilibrium each stream naturally strives for between channel erosion, sediment transport, and channel deposition. Controlling one eroding area may actually aggravate or worsen an eroding bank in another portion of the stream. Riprapping 1 mile of 5-feet high eroding streambank would cost over $50,000 and no costs are included for shaping the bank or hauling the riprap a great distance.

Another method to control gully and streambank erosion and their sediment yield is to reduce runoff from the watershed. Following is a list of management practices that will reduce runoff and sediment yield from the cropland and rangeland in Hayes Lake watershed. Because research data is limited, there will be no discussion on how much runoff and sediment will be reduced due to application of management practices.

Cropland Management Practices	Installation Costs Flat Rate
Conservation Cropping System 10/ -- Increase the amount of grass-legumes in rotation. -- Reduce the amount of summer fallow. -- Increase the amount of close-grown annual crops (winter grain and small grain). -- Reduce the amount of rowcrops.	____
Crop Residue Management -- Increase the amount of residue maintained on the land at the time of seeding. -- Control grazing of crop aftermath. -- Rotate fields from which silage is cut. -- Reduce removal of chaff and straw.	____

9/ State conservation engineer, SCS, Huron, S. Dak. Based on contract costs to repair damages to streambanks from the northern Black Hills flood of 1976. An equipment rental contract was used for riprapping. A formal contract (contractor supplies materials, labor, and equipment) was used for gabions. Hauling distance for rock may change quoted costs. Add approximately 25% if gabions are installed under water.

10/ Growing crops in combination with cultural and management measures that reduce erosion, conserve moisture, and maintain soil tilth and fertility. Costs vary with individual crops.

Cropland Management Practices	Installation Costs Flat Rate
Conservation Tillage 11/	—
-- Use a minimum number of tillage operations with minimum inversion of the soil surface to keep as much crop residue as possible on the surface.	
-- Time tillage operations so that maximum amounts of crop residue remain on the soil surface during critical erosion periods (perform fall tillage with chisels instead of plows or offset disks).	
-- Time tillage so soil is bare only immediately before seeding if crop residue is to be turned under for proper seedbed for certain crops.	
Contour Farming	$1/acre
-- Carry out all tillage operations on the contour with guidelines at terrace intervals (contouring is always applicable with terraces and could be used without terraces.)	
Contour Stripcropping	$6/acre
-- Farm on the contour and alternate strips of close grown crops (annual or sod crops) and strips of rowcrops or fallow. Strip widths at normal terrace intervals.	
Terraces	$200 to $400/1,000 ft.
-- Install terraces to reduce slope lengths. Terraces could be level or gradient depending on soil type. Gradient terraces or level terraces with open ends will need outlets into established grassed waterways ($500/acre). Terraces are normally practical for farming on land with uniform slopes.	
Critical Area Planting	$1,312/acre
-- Shape, mulch, fertilize, and seed critically eroding, sediment-producing areas in cropland.	

11/ No additional cost over conventional tillage. Tillage costs included as crop production costs.

Cropland Management Practices	Installation Costs Flat Rate
Land Conversion	\$15 to \$24/acre
-- Seeding of cropland to permanent grasses (introduced or native species) provides the most complete protection since it keeps a permanent cover on the land.	

It is estimated that 60 percent of the native rangeland is in Excellent and Good Condition in the Hayes Lake WQSA. The remaining 40 percent is in Fair and Poor Condition Classes. Following is a list of range management practices that could be applied to improve 40 percent of the rangeland:

Range Management Practices	Installation Costs Flat Rate
Grazing Land (Mechanical Treatment)	
Contour Furrowing	\$6/acre
Pitting	\$5/acre
Chiseling	\$12/acre
Disking	\$12/acre
Deferred Grazing 12/	-
Proper Grazing 12/	-
Planned Grazing System 12/	-
Range Seeding	
Warm Season Native Grasses	\$35/acre
Cool Season Native Grasses	\$25/acre
Crossfencing (4-wire barb fence)	\$1,400/mile
Critical Area Planting (Shape, mulch, fertilize, and seed critically eroding, sediment-producing areas in rangeland.)	\$1,312/acre

Pastureland and Hayland Management Practices

Grazing or haying should be managed on pastureland to insure ample growth (6-8 inches) in the spring before harvesting and to allow similar regrowth in the fall before a killing frost. Pasture or hayland is a cropland type of agriculture and occasionally needs

12/ Stocking rates should be adjusted to utilize not more than half the annual growth of the key grasses.

to be re-established. Critically eroding, sediment-producing areas in pastureland and hayland should be shaped, mulched, fertilized, and seeded. (Flat rate installation cost is $1,312/acre.)

Spring-Bull Creek

The primary sources of sediment yield in this WQSA are gullies and streambanks (55 percent). There are estimated to be over 200 gullies and almost 60 miles of eroding streambanks in this watershed. The BMP's suggested for reduction in sediment yield from streambanks and gullies are identical to those already listed in the Hayes Lake BMP's section.

Most of the native rangeland is in Good Condition Class and the remainder is in Fair Condition Class. Suggested BMP's for improving mulch and canopy cover to reduce runoff are the same as those listed in the Hayes Lake BMP's section. This is also true for pastureland and hayland BMP's.

Lake Campbell [13/]

Eighty-one percent of the total sediment yield in this WQSA was estimated to be from cropland, rangeland, and pastureland. No gullies or significant lakeshore erosion was evident and only about 6 miles of streambanks were eroding. BMP's suggested for reducing runoff and sediment yield from cropland, rangeland, and pastureland in the Hayes Lake discussion are also applicable here. Almost all the native rangeland in this watershed is in Good Condition Class.

Mina Lake

Almost all the erosion and sediment yield in Mina Lake WQSA was estimated to be from cropland, rangeland, and pastureland. The BMP's suggested for cropland in Hayes Lake [13/] are applicable to this WQSA with the exception of the following MP's:

Contour Farming	Terraces
Contour Stripcropping	Critical Area Planting

13/ It should be noted that reduction of sediment yield from cropland, rangeland, and pastureland is the goal of BMP's in Lake Campbell WQSA. In Hayes Lake and Spring-Bull Creek WQSA's, the goal of BMP's is to reduce runoff from rangeland, pastureland,and cropland, and to reduce sediment yield from gullies and streambanks. The site of application of management practices may differ in these watersheds because of the two different goals for BMP's.

The first three MP's listed here are not applicable due to short irregular slopes. All the native rangeland in Mina Lake watershed is in Fair to Good Condition Classes and BMP's are identical to those suggested for Hayes Lake. Control of lakeshore erosion is discussed in the Lake Herman BMP's section and similar measures can be applied here.

Lake Herman

Almost all the sediment yield to Lake Herman (84 percent) was estimated to be from cropland, hayland, and pastureland. There is very little native rangeland in this watershed. Suggested BMP's for cropland and pastureland in the Hayes Lake discussion (see footnote 13/) are also applicable to the Lake Herman watershed.

Applying MP's to the pastureland and hayland in this watershed should be stressed. Although land used for pastureland and hayland is only about 18 percent (7,801 acres) of the watershed, this type land is located adjacent to drainages and any eroded soil from such areas has a high chance of being delivered to a stream and becoming sediment yield. Runoff from grazed land may also have a higher concentration of nutrients than runoff from cropland.

About 8 percent of the total sediment yield to Lake Herman is from lakeshore erosion. Riprapping or gabions will control this type erosion and subsequent sediment yield. Gullies and stteambanks contribute approximately 8 percent of the sediment yield, also. Control measures for gullies and streambanks are discussed in the Hayes Lake WQSA.

Timber Creek

Almost 90 percent of the total sediment yield at the mouth of Timber Creek is from cropland and grassland. BMP's suggested for the Hayes Lake area (see footnote 13/) are also applicable to the cropland and grassland in Timber Creek WQSA.

Approximately 35 percent (123,051 acres) of this watershed is native rangeland, which is in high Fair to Good Condition Classes, hayland, and pastureland. These grasslands are often in the steeper sloping portions of the watershed near drainages, two conditions that contribute to higher than normal sediment yield. Management practices applied to these grasslands are effective BMP's.

Management practices to control the sediment yield from gullies and streambanks (10 percent of the total) are identical to those suggested for the Hayes Lake WQSA.

Twin Lakes 14/

Almost 85 percent of the total sediment yield was estimated to be from cropland in this watershed. The BMP's suggested for reducing sediment yield from cropland discussed in the Hayes Lake BMP's section (see footnote 13/) are applicable to Twin Lakes also.

The remaining 15 percent of the total sediment yield to Twin Lakes was from roads and the lakeshore. Sediment from roads was high because most of the borrow ditches are also drainage ditches throughout this watershed so any road erosion has a high chance of becoming sediment yield. There is probably no cost-effective BMP for reducing this portion of sediment yield. Control of lakeshore erosion was discussed in the Lake Herman BMP's section and those MP's are applicable in the Twin Lakes WQSA also.

Roy Lake 14/

Approximately 50 percent of the total sediment yield to Roy Lake was estimated to be from cropland. The BMP's suggested for the Hayes Lake WQSA are applicable here also for reduction of sediment yield from cropland. (See footnote 13/.) Because of short and irregular slopes and thin soils, terraces may not be applicable as BMP's in this watershed. Many fields near the lake are plowed to road ditches and other drainages. Sediment yield from these areas has a higher chance of being delivered to the lake than sediment yield from fields farther from the lake or those separated from the lake or streams by grassland.

Most of the remaining 50 percent of sediment yield in Roy Lake is from eroding lakeshores (about 9,200 feet of 8-feet high eroding bank and about 30,000 feet of 2-feet high eroding bank). The management practices discussed for reducing lakeshore sediment yield in Lake Herman WQSA are also applicable here.

14/ Only the portion of land draining directly into Twin Lakes, Roy Lake, and Lake Poinsett was analyzed in this study since sediment yields from upland portions of these watersheds were assumed to be very low.

Lake Poinsett [14]

About 68 percent of the total sediment yield in Lake Poinsett WQSA was estimated to be from cropland. Almost 6 percent was from the grassland in the watershed. MP's suggested for Hayes Lake are all applicable to this WQSA, also (see footnote 13/). Emphasis should be placed on application of MP's to cropland.

The remaining sediment yield is almost all from eroding lakeshores (approximately 50,000 feet of 3-feet high eroding bank). The Lake Herman discussion on controlling sediment yield from lakeshores is also applicable here.

Oakwood Lakes

Lakeshores contribute over 60 percent of the total sediment yield to this WQSA (about 60,000 feet of 2-feet high eroding bank and about 32,000 feet of 10-feet high eroding bank). The management practices to control sediment yield from lakeshores discussed in the Lake Herman BMP's section are also applicable here.

The remaining 40 percent of sediment yield in the Oakwood Lakes WQSA is primarily from cropland. The MP's discussed in the Hayes Lake WQSA are all applicable to this area, also (see footnote 13/). Those fields closest to existing drainages and near the lake itself should have priority in BMP application.

There is very little native rangeland in this WQSA but the MP's discussed in the Hayes Lake section relating to hayland and pastureland are also applicable in this area.

Epilogue

There has been concern voiced in South Dakota over increased rates of sediment deposition and greater concentrations of nutrients in our waters today than in the past. A subsequent concern has been accelerated eutrophication of our lakes. A review of water quality data for lakes in eastern South Dakota reveals that most data has been collected after 1970. [1/] Only four water quality sample analyses were noted prior to 1950 and only two of those four were analyzed for nutrients. STORET water quality data shows that suspended sediment samples have been collected on the James River for 15 years (1960-1974) and on the Big Sioux River for 6 months (1966-1967). Data on smaller streams are essentially nonexistent. Better sediment records exist for the five major rivers in western South Dakota but only for approximately 30 years or less (White River at Oacoma, 1939-1942 and 1944-1971; all other rivers, from 1947 or later and discontinuously on into the 1960's and early 1970's).

What the above indicates is that there is not enough water quality data of long enough record for anyone to reasonably compare today's water quality with that of the past. Studies of fossil diatoms and pollen, coupled with radiocarbon-age dates, in Pickerel Lake in northeastern South Dakota indicate that the lake was eutrophic from 4,000 to 8,000 years ago. [2/,3/] The Haworth report adds that "... the diatom history shows a natural progression toward eutrophication." A water quality study in Iowa concluded that Iowa's glacial lakes have been eutrophic for several thousands of years. [4/] One of their

1/ "Chemical Inventory of the Lakes of the Coteau," compiled by East Dakota Conservancy Sub-District, Brookings, S. Dak., 1977.

2/ Watts, W. A., and Bright, R. C., (1968), "Pollen, Seed, and Mollusk Analysis of a Sediment Core from Pickerel Lake, Northeastern South Dakota," Geological Society of America Bulletin Vol. 79, pp.855-876.

3/ Haworth, E.Y., (1972), "Diatom Succession in a Core from Pickerel Lake, Northeastern South Dakota," Geological Society of American, Bulletin, Vol. 83, pp. 157-172.

4/ Bachman, R. W., and Jones, J. R., (1974), "Water Quality in the Iowa Great Lakes," Dept. of Zoology and Entomology, ISU, Ames, Iowa.

references adds that "There are no physical or floristic changes in the sediments of Lake West Okoboji indicative of severe changes in the sedimentation rate or trophic level of the lake, even in recent deposits, which would reflect changes due to the activities of man." 5/

Sediment samples from Lake Herman have been collected by the SCS and a team from the Science and Education Administration (SEA). The sediment samples will be analyzed by the SEA's sedimentation laboratory at Oxford, Mississippi, for concentrations of Cesium-137 (a product of nuclear testing fallout) to determine the rate of sedimentation in Lake Herman. This study was funded by the South Dakota Department of Environmental Protection. The final analyses have not been completed at this date but preliminary indications are that the rate of sedimentation may be less than that reported in literature.

Other researchers have recently been working with various aspects of the nutrient problem and agricultural practices:

"Losses of plant nutrients in soil eroded from cultivated land may be similar to average losses that would occur naturally if the area were in pristine prairie that was periodically subjected to fire. ... The average concentrations of solution-phase Ca, Mg, K, Na, P, NO_3-N, and NH_4-N in runoff from cultivated erosion plots was similar to concentrations in runoff from prairie... In addition, the concentrations in runoff from fertilized oats, corn, and alfalfa plots were similar to those from unfertilized fallow... Although the erosion is a management problem for agriculture, the regional significance on water quality has been overemphasized. ...If the volume of runoff into the stream was less, the soluble ions removed from vegetation and soils would be at a higher concentration in the stream. Lakes and streams then would contain not only a small volume but a lower quality water." 6/

5/ Stoermer, E.F., (1963), "Post-Pleistocene Diatoms from Lake West Okoboji, Iowa," unpub. PH.D. thesis, Library, ISU of Science and Technology, Ames, Iowa, 214 pp.

6/ White, E. M., and Williamson, E.J., (1973) "Plant Nutrient Concentrations in Runoff from Fertilized Cultivated Erosion Plots and Prairie in Eastern South Dakota," South Dakota Agricultural Experiment Station, Journal Series 1142, reprinted in Journal of Environmental Quality, Vol. 2, No. 4, 1973.

"Sediment losses were considerably lower than anticipated... Most of the nutrients were found to be soluble and/or associated with snowmelt runoff." 7/

These notes point out differences between conceptions of historic versus present rates of sediment yield and nutrient concentrations in our Nation's waters. Comparisons of these rates are interesting but irrelevant since man can reduce the present rates through selective application of various management practices. Although it is difficult to quantify the improvement in the environment, it is still generally believed that improvements do result.

The goals of section 208 water quality management plans are to make all our Nation's waters "fishable and swimmable." This report has attempted to outline paths towards accomplishment of those goals. It is only the start of what may be a longer journey than what the authors of section 208 envisioned. The following perspective should be kept in mind when implementation becomes the next step on that journey:

> "If we are to make full use of the earth's resources and at the same time maintain a viable environment we must understand the natural forces and processes at work in the earth, the rivers, the oceans, and the atmosphere. We must know how these forces, processes, and materials interact and how and to what extent we perturb them in our activities. In spite of the warnings we frequently hear, there is nothing inherently wrong in changing the so-called balance of nature. Nature herself does it continually and man has been doing it with good, bad, and indifferent results since the discovery of fire and agriculture. What is dangerous now, with our enormous power to modify the earth and its processes, is to act in ignorance of the consequences." 8/

7/ Dornbush, J.N., Andersen, J. R., and Harms, L.L., (1974), "Quantification of Pollutants in Agricultural Runoff," Project No. R-800400, EPA-660/2-74-005, prepared for Office of Research and Development, U.S., EPA, Washington, D. C., 20460, 95 pages.

8/ McKelvey, V.E., (1972), "Earth Scientists - Front and Center!" April 17, 1972, quote from USGS Yearbook Fiscal Year 1977.

APPENDIX

Use of Universal Soil Loss Equation

The factors in the Universal Soil Loss Equation (USLE) are described below. 1/

A = RKLSCP = Soil loss or erosion rate in tons/acre/year
R = Rainfall factor (a measure of erosive force of rain in an area)
K = Soil erodibility factor
LS = Topographic factor (expresses the combined effects of slope length "L" and percent of slope "S")
C = Cropping management (cover) factor
P = Erosion control practice factor

Conservation treatment measures to reduce erosion are reflected in the factors "LS" "C" and "P." Terraces shorten the length of slope, which lowers the "LS" factor. The "C" factor is influenced by changes in crop rotations, residue management, or tillage systems. Contour farming lowers the "P" factor. The effect of such changes on erosion rates in a farm field is illustrated by the following example:

The soil is Kadoka silt loam on a field in Shannon County, South Dakota. The field slope is 6 percent and the slope length is 300 feet. The crop rotation is winter wheat-summer fallow.

FARM OPERATION	USLE FACTORS					SOIL LOSS OR EROSION RATE Tons/Acre/Year
	R	K	LS	C	P	
Summer-fallow operations with disk-type implements, leaving about 200 pounds of wheat residue on the soil surface at planting time						
- Farmed up and down hill	50	0.32	1.2	0.36	1.0	7
- Terraced (100-foot interval) farmed parallel to terraces.	50	0.32	0.67	0.36	0.5	2
Summer-fallow operations with subsurface tillage implements, leaving about 750 pounds of wheat residue on the soil surface at planting time						
- Farmed up and down hill	50	0.32	1.2	0.20	1.0	4
- Terraced (100-foot interval) farmed parallel to terraces	50	0.32	0.67	0.20	0.5	1

1/ South Dakota Technical Guide III-1, "Estimating Soil Loss Resulting from Water and Wind Erosion in South Dakota," USDA, SCS, Huron, S. Dak., June 1977.